Climatological observations for twenty-four hours ending at 7:17 a. m. local (or 1 p. m. Greenwich) time, October, 1899.

Date.	Temperature. Maximum.	Temperature. Minimum.	Wind. Prevailing direction.	Wind. Maximum force.	Average cloudiness.	Total rainfall.	Rainfall at Sapoa.
	°	°				Inches.	Ins.
1	87	79	ne, e.	3	6	T.	0.00
2	87	76.5	n, e.	2	4	0.00	0.00
3	89	75	n, ne.	3	5	0.00	0.00
4	84	77	n, w.	4	5	0.84	0.00
5	86	75	sw.	3	6	0.00	0.00
6	87.2	75	ne.	2	7	0.65	0.03
7	87.4	75.5	nne.	2	3	0.20	0.00
8	86.5	76	nne.	3	5	0.95	0.43
9	86.4	76	ne.	4	6	0.07	0.10
10	86.3	77	ne.	3	5	0.00	0.05
11	87.5	74.5	ne.	2	6	0.10	0.10
12	84.5	76	wnw.	3	7	0.36	0.01
13	87	75	nw by n.	2	8	1.99	0.28
14	86	75	nnw.	3	8	0.65	1.67
15	85	76	n to se.	2	8	0.07	0.02
16	82	75	w, nw.	3	9	0.50	0.10
17	82.3	75	sw.	3	8	0.22	0.02
18	85	75	w, nw.	4	6	0.01	0.00
19	86	74	ne.	4	7	0.09	0.17
20	82	78	ne.	4	10	0.00	0.86
21	78	75	ne.	2	10	0.07	0.00
22	85	73	ne.	1	6	0.40	0.10
23	83.3	75	sw.	3	5	0.01	0.14
24	83	74.5	sw.	3	9	0.10	0.00
25	80	74	sw.	4	10	0.01	0.39
26	82	76	sw.	6	9	2.84	0.24
27	80	75	sw.	6	8	4.21	0.99
28	80	75	sw.	6	10	1.70	0.71
29	81.2	75	sw.	3	10	0.80	0.09
30	83.1	74.5	sw.	1	7	0.00	0.00
31	84	75.5	ne.	2	8	1.02*	0.00
Sums	84.3	75.4				19.86	6.45
Means							
Departures						+2.90	

* An additional 0.53 inch that fell later is to be carried over to November.

In addition to his record for Rivas, Mr. Earl Flint kindly also sends the rainfall record for Sapoa, which is printed above. The fall at Sapoa was unusually light; that at Rivas, as used by Mr. Flint (20.39 inches, including the 0.53 inch that fell late on the 31st) was 3.43 inches above normal.

METEOROLOGY OF PANAMA.

By Gen. HENRY L. ABBOT (dated Paris, November 11, 1899).

The following additional data are in continuation of my previous contributions to the climatology of Panama and Colon. (See MONTHLY WEATHER REVIEW, May, p. 198, and July, p. 302).

MONTHLY RAINFALL FOR 1899.

The new station, Alhajuela, is on the River Panama, about 18 miles above Gamboa. The height of the instruments is about 50 meters above sea level. The locations of Bohio and Gamboa were given in my previous communication. The following figures for rainfall bring the records up to date:

Stations.	July, 1899.		August, 1899.		September, 1899.	
	Mm.	Inch.	Mm.	Inch.	Mm.	Inch.
Bohio	451	17.76	330	12.99	226	8.90
Gamboa	240	9.45	278	10.94	342	13.46
Alhajuela	297	11.69	259	10.20	205	8.07

At Alhajuela, during the last 19 days of June, 34 mm., or 1.34 inches, fell.

HOURLY TEMPERATURES IN 1899.

The records made by the self-registering thermometer and barometer at Alhajuela have been read off and the means taken by myself, with the results given in the following table:

1999.	Temperatures. July.		August.		September.		Barometric pressures. July.		August.		September.	
	° C.	° F.	° C.	° F.	° C.	° F.	Mm.	Ins.	Mm.	Ins.	Mm.	Ins.
1 a.m.	25.5	77.9	24.8	76.6	24.7	76.5	760.0	29.92	759.4	29.90	759.9	29.92
2 a.m.	25.3	77.5	24.7	76.5	24.5	76.1	759.7	29.91	759.0	29.88	759.5	29.90
3 a.m.	25.2	77.4	24.5	76.1	24.4	75.9	759.5	29.90	758.8	29.88	759.4	29.90
4 a.m.	25.0	77.0	24.4	75.9	24.2	75.6	759.4	29.90	758.9	29.88	759.6	29.91
5 a.m.	24.9	76.8	24.4	75.9	24.1	75.4	759.6	29.91	759.2	29.89	759.8	29.91
6 a.m.	24.7	76.5	24.3	75.7	24.2	75.6	759.8	29.91	759.5	29.90	760.2	29.93
7 a.m.	24.6	76.3	25.4	77.7	25.7	78.3	760.1	29.93	759.8	29.91	760.6	29.94
8 a.m.	25.1	77.2	26.6	80.0	27.4	81.3	760.3	29.93	760.2	29.93	760.9	29.96
9 a.m.	25.7	78.3	28.4	83.1	29.1	84.4	760.5	29.94	760.2	29.93	760.9	29.96
10 a.m.	26.8	80.2	29.1	84.4	30.1	86.2	760.5	29.94	760.1	29.93	760.6	29.94
11 a.m.	27.5	81.5	29.8	85.6	31.0	87.8	760.3	29.93	759.8	29.91	760.2	29.93
Noon	28.2	82.8	29.9	85.8	31.2	88.2	760.0	29.92	759.4	29.90	759.7	29.91
1 p.m.	28.5	83.3	29.5	85.1	30.5	86.9	759.7	29.91	759.0	29.88	759.2	29.89
2 p.m.	28.3	82.9	29.3	84.7	29.9	85.8	759.2	29.89	758.6	29.87	758.9	29.88
3 p.m.	28.5	83.3	29.2	84.6	29.3	84.7	758.9	29.88	758.3	29.86	758.8	29.88
4 p.m.	28.2	82.8	28.8	83.8	28.8	83.8	758.9	29.88	758.2	29.85	758.8	29.88
5 p.m.	27.7	81.9	28.1	82.6	28.2	82.8	759.0	29.88	758.4	29.86	759.0	29.88
6 p.m.	27.1	80.8	27.3	81.1	27.1	80.8	759.3	29.89	758.7	29.87	759.4	29.90
7 p.m.	26.7	80.1	26.7	80.1	26.4	79.5	759.7	29.91	759.1	29.89	759.8	29.91
8 p.m.	26.4	79.5	26.3	79.3	25.9	78.6	760.2	29.93	759.5	29.90	760.3	29.93
9 p.m.	26.3	79.3	25.6	78.1	25.6	78.1	750.5	29.94	759.9	29.92	760.6	29.94
10 p.m.	26.3	79.3	25.4	77.7	25.3	77.5	760.7	29.95	760.1	29.93	760.6	29.94
11 p.m.	26.1	79.0	25.2	77.4	25.0	77.0	760.6	29.94	759.9	29.92	760.5	29494
Midnight	25.8	78.4	25.0	77.0	24.8	76.7	760.4	29.94	759.7	29.91	760.2	29.93
Means	26.4	79.5	26.8	80.2	27.0	80.6	760.0	29.92	759.3	29.89	759.9	29.92
Maximums	31.0	87.8	34.5	94.1	35.9	96.6	762.2	30.01	761.5	29.98	762.8	30.03
Minimums	22.0	71.6	21.9	71.4	22.0	71.6	756.7	29.79	756.5	29.78	757.0	29.80

The records for these three months are complete, except that during July six days of temperature and three days of pressure records are missing. Nothing is said as to the nature of the self registers, but they are presumably of the Richard pattern and checked by occasional observations of the standard instruments. The observations and records have been made or collected by the officers of the new Panama Canal Company.

TEMPERATURES AT DULUTH, MINN.

By H. W. RICHARDSON, Local Forecast Official (dated October 28, 1899).

Temperature records, Duluth, Minn.

Month.	(1) Mean temperature.	Maximum. Temperature	Maximum. Day.	Maximum. Year.	Minimum. Temperature	Minimum. Day.	Minimum. Year.	(2) Maximum. Times.	(2) Maximum. Above.	(3) Minimum. Times.	(3) Minimum. Below.	(4) 20° falls to 0°.	Consecutive days. (5) Maximum. 80°	Consecutive days. (6) Minimum. 0°
	°	°			°				°		°	°	°	°
January	10.5	51	28, 14	1877, 1894	−41	2	1885	3	50	15	0	2	0	8
February	14.4	58	26	1895	−36	9	1899	3	55	11	0	1	0	6
March	23.6	64	23	1889	−26	19	1875	3	60	5	0	1	0	3
April	38.1	81	29	1891	+3	1	1881	4	75	16	32	0	‡	0
May	48.4	88	9	1896	25	1	1888	8	85	2	32	0	1	0
June	57.7	92	28, 19	1883, 1893	33	8, 6	1885, 1897	5	90	2	40	0	2	0
July	66.0	99	1	1883	45	1, 2	1888, 1895	3, 5	90, 95	3	50	0	3	0
August	64.8	95	25	1888	40	31	1886	11	90	2	50	0	3	0
September	56.5	94	1	1894	29	29	1899	3	90	1	32	0	1	0
October	44.8	80	7	1886	+8	31, 25	1878, 1887	9	75	7	32	0	‡	0
November	28.8	65	7, 1	1874, 1887	−29	29	1875	6	60	2	0	1	0	2
December	17.6	54	12	1891	−34	25	1879	4	50	8	0	1	0	5
Annual	39.3	99	*	1883	−41	†	1885	....	....	....	....	6	12	24

*July 1. † January 2.

‡ The maximum temperature of 80° or more occurred twice in 26 years in April and June.

(1) The first column relates to the 29 years, November, 1870, to October, 1899, inclusive, the rest of the table relates to the 26 years, November, 1873 to October, 1899.

(2) The total number of times the temperature equaled or exceeded 50° or other specified degrees.

(3) The average number of times the temperature equaled or fell below 0° or other specified degrees.

(4) Average number of times that the temperatures fell 20° or more in twenty-four hours, and reached zero or lower.

(5) The average of the greatest number of consecutive days whose maximum temperature was 80° or above.

(6) The average of the greatest number of consecutive days whose minimum temperature was zero or below.

The following temperature data for Duluth were prepared for publication in a local paper and, at the request of the Editor of the REVIEW, have been expanded slightly, as shown in the preceding table. A study of the figures here given will show that the climate at the head of Lake Superior is invigorating and healthful. Our summers and autumns are usually very pleasant, the summers especially so, and with an appreciable absence of those two weeks of continuous and debilitating sieges of warmth that one encounters a little further southwest and south. To be sure our winters are long, but the cold is steady. The early portion of the spring is generally rather unpleasant, but I have experienced fully as bad, or worse, elsewhere.

Average temperature of spring months, 36.7°; summer, 62.8°; autumn, 43.4; winter, 14.2°. Average of the warmest spring, 44.4; warmest summer, 67.2°; warmest autumn, 47.3°. Average of the coldest spring, 30.9; coolest summer, 59.1°; coldest autumn, 39.1°; coldest winter, 6.2°. Spring months: March, April, and May; Summer: June, July, and August; Autumn: September, October, and November; Winter: December of previous year, January and February following.

Greatest number of days in any month, for twenty-six years, with minimum temperatures of zero or below: January, 24; February, 24; March, 12; November, 8; December, 19. Least number of days in any month with minimum temperatures of zero or below: January, 3; February, 0; March, 0; November, 0; December, 0.

Greatest number of days in any summer month with maximum temperatures of 90° or above: June, 1; July, 5; August, 2.

Number of years maximum temperature of 90° or above did not occur: June, 22; July, 12; August, 18; September, 23.

The minimum temperature usually falls to 32° or below, 168 times each year, and to zero and below 41 times.

Number of actual falls in temperature of 20° or more to 32° and below, twenty-six years' record: April, 6 times; May, 3; September, 0; October, 3.

NOTES BY THE EDITOR.

THE RAIN GAGE AND THE WIND.

On page 454 we give an interesting letter from G. J. Symons, Esq., the well known and most eminent authority on British rainfall, and in order that the influence of the wind on the catch of the gage may be more fully appreciated, we reprint the greater part of a study of the subject made by the Editor in 1887. This paper was read in full before the Philosophical Society of Washington, November 24, 1888. Some portions were published in the American Meteorological Journal in 1889–90, Vol. VI, pp. 241–248 and in Symons's Meteorological Magazine, Vol. XXIV, pp. 130–135, and in the Proceedings of the International Meteorological Congress at Paris, September, 1889, Vol. II, pp. 241–248. It was, however, not fully published until 1893, when it appeared as an appendix to Bulletin No. 7 of the Forestry Division of the Department of Agriculture. As the edition of that bulletin is now exhausted, and as the subject of this study is of the highest importance to others besides foresters, the present reprint will respond to the needs of all.

Mr. Symons writes that he has just started a Nipher shielded gage on the Cheviots on the flat top of a conical hill about 2,000 feet high, by the side of an ordinary gage which has been there four or five years; the records will probably begin to be published in about two years.

With regard to the accuracy of rainfall measurements viewed simply as comparable data, two matters have been studied experimentally, namely, the size and style of the gage and the altitude above ground. With regard to size it is satisfactorily shown that no error of more than 1 per cent systematically attaches to gages of the ordinary forms and of diameters anywhere between 4 and 44 inches. With regard to the altitude it must be conceded that for a hundred years it has been known in a general way that observations by gages at various heights above the ground are not comparable with each other. The remarkable influence of altitude was first brought to the attention of the learned world by Heberden, who, in a memoir in the transactions of the Royal Society of London, in 1769, stated that a gage on Westminster Abbey over 150 feet above the ground caught less than half as much as a gage at the ground. Since his day numerous others have instituted similar observations in their respective localities. Usually they have been satisfied with observing only one or two elevated gages, but of late years, in order to fully elucidate the subject, more elaborate measurements have been made; thus Phillips and Gray, at York, England, have observed at eight different altitudes including the gage on the tower of York Minster.

Bache, at Philadelphia, observed four gages on top of a square tower, and four others on poles above them; Col. Ward, at Calne House, Wiltshire, observed ten pairs of gages at elevations of 20 feet or less, each pair consisting of an 8-inch and a 5-inch gage; Bates, at Castleton Moor, similarly observed ten pairs of gages; Chrimes, at Rotherham Reservoir, six gages, at elevations of 25 feet or less; (——?) at Hawsker, four 3-inch gages, at altitudes of 10 feet or less; Wild, at St. Petersburg, six 10-inch gages, at altitudes of 5 meters or less, and one at an altitude of 25 meters. A very laborious series of six or eight gages at altitudes of 40 feet or less has, to my knowledge, been carried on for some years by Fitzgerald, at Chestnuthill, near Boston, but the results are not yet published.

It will be seen, therefore, that abundant observational data are at hand for the elucidation of the peculiarities of the rain gage, and the results that can be deduced from such data command our immediate attention. Whatever mystery has hitherto attached to the undoubted fact that elevated gages catch less rain is now fully explained away. This phenomenon is of the nature of an error in the rain gage depending upon the force of the wind that strikes it, and as will be seen, now that the knowledge of the source of error has been established, the method of correcting or preventing it becomes simple.

It will be remembered that Benjamin Franklin, upon reading Heberden's memoir, at once, in 1771, in a letter to Percival explained his results by the hypothesis that falling cold rain drops condense the moisture they meet with in the warmer lower strata, and that Phillips, in 1834, independently revived this hypothesis as explaining the increase of rainfall. A much truer explanation had been suggested by Meikle, in the Annals of Philosophy for 1819, and by Boace (Annals of Philosophy, 1822), to the effect that the deficiency is due to the velocity of the wind and to the fact that the gage stands as an obstacle to the wind; also Howard showed that the strength of the wind affected the higher gage. But these minor notices seem to have produced but little effect among the meteorologists, and it remains for W. B. Jevons, Phil. Mag., 1861, Vol. XXII, to demonstrate that the Franklin-Phillips hypothesis was highly unsatisfactory, and in fact impossible, and that the true reason for diminution of apparent rainfall with the height of gage is the influence of eddies of wind around the building and the mouth of the gage. This explanation had, however, been also quite clearly pointed out by Prof. Bache, who had shown that eddies around the top for the tower affected the distribution ofthe rainfall on the tower. Alexander Dallas Bache and Joseph Henry were intimately associated in their scientific work as early as 1835 (and especially after Henry came to Washington, in 1847), and the latter had adopted that which is now called Jevon's explanation, although as we have seen it was first given by Meikle, 1819, and subsequently independently arrived at by many others. This theory was definitely adopted and disseminated by Henry at least as early as 1853 in connection with his instructions to Smithsonian observers.

The essence of this explanation may be stated thus: In the case of ordinary rainfalls we invariably have the air full of large and small drops, including the finer particles that constitute a drizzling mist and the fragments of drops that are broken up by spattering. All these are descending with various velocities which, according to Stokes, depend on their size and density and the viscous resistance of the air; the particles of hail descend even faster than drops of water and the flakes of snow descend slower than ordinary drops. Now when the wind strikes an obstacle the deflected currents on all sides of the obstacle move past the latter more rapidly; therefore, the open mouth of the rain gage has above it an invisible layer of air whose horizontal motion is more rapid than that of the wind a little distance higher up. Of the falling raindrops the larger ones may descend with a rapidity sufficient to penetrate this swiftly moving layer, but the slower falling drops will be carried over to the leeward of the gage, and failing to enter it will miss being counted as rainfall, although they go on to the ground near by. Evidently the stronger the wind the larger will be the proportion of small drops that are carried past the gage; or again, the larger the proportion of small drops and light flakes of snow that constitute a given shower, the more a gage will lose for a given velocity of the wind. In brief, the loss will depend both upon the velocity of the wind and